(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 November 2004 (11.11.2004)

PCT

(10) International Publication Number
WO 2004/097072 A1

(51) International Patent Classification[7]: C25B 1/04, 9/06, C25D 15/00

(21) International Application Number: PCT/IB2004/050557

(22) International Filing Date: 30 April 2004 (30.04.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2002/9600 30 April 2003 (30.04.2003) ZA

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

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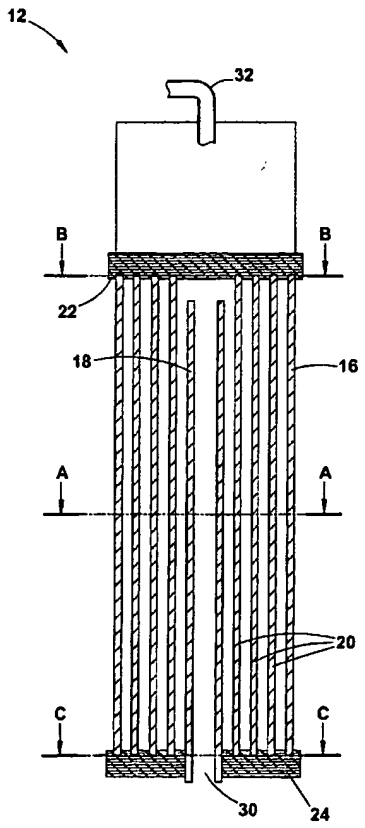
(54) Title: METHOD AND APPARATUS FOR PRODUCING COMBUSTIBLE FLUID



(57) Abstract: This invention relates to a method and apparatus for producing combustible fluid at an efficiency rate of above 65%. The apparatus (10) comprises an electrolysing cell (12) for electrolysing the aqueous electrolytic solution and a pulsed current to the electrolysing cell (12). The electrolysing cell (12) includes a first electrode (16) and a second electrode (18) spaced from the first electrode (16) and a plurality of intermediate electrically floating electrodes (20) disposed between the first and second electrodes (16) and (18) respectively. The pulsing means pulses the current to the electrolysing cell (12) at a frequency of 0.75 Hz and at a duty cycle 28%.

WO 2004/097072 A1

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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METHOD AND APPARATUS FOR PRODUCING COMBUSTIBLE FLUID

INTRODUCTION AND BACKGROUND TO THE INVENTION

This invention relates to a method and apparatus for producing combustible fluid. More particularly this invention relates to a method and apparatus for producing hydrogen and oxygen through the electrolysis of an aqueous electrolytic solution.

In this specification, the term "combustible fluid" includes within its scope combustible gas containing predominantly hydrogen and oxygen.

Numerous apparatus for producing combustible fluid from aqueous electrolytic solutions are known. A common disadvantage of the know apparatus is that the ratio between power consumed and combustible fluid produced is unfavourable, so that their efficiency are relative low, i.e. the energy produced is less than 65% of the energy consumed in the process.

OBJECT OF THE INVENTION

It is accordingly an object of the present invention to provide an alternate method and apparatus for the production of combustible fluid overcoming the above disadvantage by producing combustible fluid at relatively higher efficiency

rates, i.e. the energy produced is substantially more than 65% of the energy consumed in the process.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided apparatus for the production of combustible fluid from an aqueous electrolytic solution comprising:

- an electrolysing cell for electrolysing an aqueous electrolytic solution, the electrolysing cell including a first electrode; and a second electrode spaced from the first electrode; and
- a pulsing means for pulsing a current to the electrolysing cell and having a duty cycle of less than 50%.

The pulsing means may pulse the current at a duty cycle of between 20% and 40%, preferably 28%.

The pulsing means may include a power supply; a chopper circuit; a capacitor; an inductor; and a diode.

The pulsed current may be pulsed at a frequency of between 0.65 Hz and 0.85 Hz, preferably 0.75 Hz.

The capacitor may have a capacitance of between 200 mF and 350 mF, preferably 272 mF.

The inductor may have an inductance of between 3 mH and 7 mH, preferably 5 mH.

The power supply may supply a DC voltage of 12 V.

The electrolytic solution may be in the form of a sodium hydroxide solution in water.

The first electrode may be an outer electrode, with the second electrode being an inner electrode disposed within the outer electrode.

The pulsing means may be connected to the first and second electrodes.

A plurality of intermediate floating electrodes may be disposed between the first and second electrodes, the intermediate electrodes not being connected directly to the pulsing means.

The electrodes may be interposed between two insulators.

A passage may be provided in the form of a plurality of annular channels for the electrolytic solution defined between the first or outer electrode, the intermediate electrodes, and the second or inner electrode.

The electrodes may be tubular and may be arranged concentrically with each other.

According to a second aspect of the invention there is provided a method for the production of combustible fluid from an aqueous electrolytic solution including the steps of:

- providing an aqueous electrolytic solution;
- disposing the solution in an electrolysing cell between two spaced electrodes;
- applying a pulsed current to the electrolysing cell, the current having a duty cycle of less that 50%; and
- electrolysing the electrolytic solution.

The pulsed current may have a duty cycle of between 20% and 40%, preferably 28%.

The step of applying a pulsed current to the electrolysing cell may include the further step of pulsing the current at a frequency of between 0.65 Hz and 0.85 Hz, preferably 0.75 Hz.

The step of disposing the solution in an electrolysing cell may include the further step of disposing the electrolytic solution between a first outer electrode, a second inner electrode disposed within the outer electrode, and a plurality of intermediate floating electrodes disposed between the first and second electrodes.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described further by way of a non-limiting example with reference to the accompanying drawings wherein:

figure 1 is a schematic representation of an apparatus 10 according to a preferred embodiment of the invention for the production of combustible fluid from an aqueous electrolytic solution, the apparatus including an electrolysing cell 12 and a pulsing means 14;

figure 2 is a longitudinal-sectional side view of the electrolysing cell 12 shown schematically in figure 1;

figure 3 is a cross-sectional view of electrodes 16, 18 and 20 along lines A-A in figure 2 of the electrolysing cell 12;

figure 4 is a cross-sectional view of an upper insulator 22 along lines B-B in figure 2 of the electrolysing cell 12;

figure 5 is a cross-sectional view of a lower insulator 24 along lines C-C in figure 2 of the electrolysing cell 12;

figure 6 is a circuit diagram of the pulsing means 14 shown schematically in figure 1; and

figure 7 is a graph depicting current and voltage waveforms over two periods as measured across the electrolysing cell.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring to figure 1, an apparatus according to a preferred embodiment of the invention for producing combustible fluid from an aqueous electrolytic solution is generally designated by reference numeral 10.

The apparatus 10 comprises an electrolysing cell 12 for electrolysing the aqueous electrolytic solution and a pulsing means 14 for providing a pulsed current to the electrolysing cell 12.

Referring further to figures 2 to 5, the electrolysing cell 12 includes a first electrode 16 and a second electrode 18 spaced from the first electrode 16. The first electrode 16 is an outer electrode providing a housing for the electrolytic solution, with the second electrode 18 being an inner electrode disposed within the outer electrode 16. A plurality of intermediate electrically floating electrodes 20 are disposed between the first and second electrodes 16 and 18 respectively.

The electrodes 16, 18 and 20 are tubular and are arranged concentrically with each other as shown in detail in figure 3. The electrodes 16, 18 and 20 are further arranged between two insulators namely an upper insulator 22 and a lower insulator 24.

The upper insulator 22, shown in detail in figure 4, is in the form of a cross-shaped body of a dielectric material such as glass or Perspex. The upper insulator 22 defines a plurality of grooves 26 in which the upper ends of the electrodes 16 and 20 are located. The grooves 26 retain the electrodes 16 and 20 in position and a distance of 7,5 mm apart.

The inner electrode 18 does not extend to the upper insulator 22. The inner electrode 18 is shorter than the outer electrode 16 and the intermediate floating electrodes 20 and serves as an overflow for the electrolytic solution contained within the electrolytic cell 12.

The lower insulator 24 is in the form of a circular disc of a similar dielectric material and is shown in detail in figure 5. The lower insulator 24 defines a plurality of concentrically arranged circular grooves 28 in which the lower ends of the electrodes 16 and 20 are retained. The lower insulator 24 further defines an opening 30 through its centre. The inner electrode 18 extends through the opening 30, the arrangement being such that the electrolytic solution, which overflows into the inner electrode 18, is passed out of the electrolysing cell 12 via the opening 30.

The electrolysing cell 12 is further provided with a combustible fluid outlet 32 towards the top of the electrolysing cell 12. The combustible gas produced by the apparatus 10, in use, escapes from the electrolysing cell 12 via the outlet 32 and is used as a source of energy in any number of applications, such as for generating heat or electricity, or for running an internal combustion engine of a vehicle.

Referring now to figure 6, the pulsing means 14 includes a power supply Vs1; a chopper circuit 15; a capacitor C1; an inductor L1; and a diode D3. The capacitor C1 has a capacitance of 272 mF and the inductor L1 has an inductance of 5 mH. The power supply Vs1 supplies a dc voltage of 12 V. This voltage is fed to capacitor C1, passed through the inductor L1 and fed to the IGBT (Insulated Gate Bipolar Transistor) of the chopper circuit 15. The chopper circuit 15 pulses the current and voltage at a frequency of 0.75 Hz and a duty cycle of 28%. The pulsed current and voltage passes through the diode D3 to the electrolysing cell 12. The pulsing means 14 is connected to the outer and the inner electrodes 16 and 18 respectively, and not to the intermediate floating electrodes 20. The current across to the electrolysing cell 12 consists of an "on-time" of approximately 0.4 s and an "off-time" of 0.93 s, thus having a period of 1.33 s. During the "on-time", the voltage across the electrolysing cell 12 is approximately 9 V and during the "off-time" the voltage drops to approximately 3V. A graph depicting the current and voltage waveforms across the electrolysing cell 12 is shown in figure 7.

The electrolytic solution is in the form of a 3% sodium hydroxide solution in water on a mass per mass basis. The sodium hydroxide is 99% pure. However, there are numerous other electrolytic solutions known in the art that would also suffice.

In use, the electrolysing cell 12 is filled with the electrolytic solution until the level of the solution reaches the upper end of the inner electrode 18 and starts to overflow. The pulsing means 14 is switched on, so that a pulsed current is provided to the electrolysing cell 12. The chopper circuit 15 continuously switches the current on and off at a frequency of 75 Hz and at a duty cycle of 28%. Electrolysis takes place in the electrolysing cell 12 and the gas produced by this process escapes from the cell 12 via the outlet 32.

During operation of the apparatus 10, the electrolysing cell 12 acts as a capacitor, thus the voltage across the electrolysing cell 12 does not change rapidly to zero during the "off-time", but rather drops gradually to approximately 3 V. The electrolysing cell 12 therefore continues to produce gas even when it has no input current.

The inductor L1 smoothes the flow of current through the circuit and prevents or restricts any rapid current changes to the electrolysing cell 12. The capacitor C1 is a filter to ensure that there are no voltage spikes from the supply Vs1 during the switching operation of the chopper circuit 15. The diode D3 ensures that the voltage from the electrolysing cell 12 is not drained during the "off-time" of the chopper circuit 15.

From time to time the level of the electrolytic solution in the electrolysing cell 12 is topped up.

EXAMPLE

An experiment to measure the time-averaged power dissipated by the electrolysing cell 12 during electrolysing of the electrolytic solution was conducted as is described above.

RESULTS

The voltage and current across the electrolysing cell 12 was measured and the instantaneous power as a function of time was calculated by multiplying the voltage and current over one period. The time averaged power was calculated as the average of the instantaneous power over one period. The time was also measured to produce 500 ml of combustible gas.

The following results were obtained:

Time-averaged power dissipated by electrolysing cell	13.98 W
Time to generate 500 ml combustible fluid	206 s
Gas production	0.148 l/kWmin
Efficiency	96 %

The efficiency was calculated by dividing the gas production (l/kWmin) by 10.999 l/kWmin. 10.999 l/kWmin is a reference value used at 1750 m above sea level. Therefore should the gas production at 1750 m above sea level be 10.999 l/kWmin, the efficiency would be 100%.

The applicant has found that the apparatus 10 performs far more superior than the prior art since it utilises relatively low voltage and current and is relatively much more efficient in the production of combustible fluid than any of the prior art apparatus hitherto known to the public. The apparatus 10 is further more compact and relatively easy to operate compared to the prior art.

It will be appreciated that variations in detail are possible with a method and apparatus for producing combustible fluid according to the invention without departing from the scope of the appended claims.

CLAIMS

1. Apparatus for the production of combustible fluid from an aqueous electrolytic solution comprising:
   - an electrolysing cell for electrolysing an aqueous electrolytic solution, the electrolysing cell including a first electrode; and a second electrode spaced from the first electrode; and
   - a pulsing means for pulsing a current to the electrolysing cell and having a duty cycle of less than 50%.

2. Apparatus according to claim 1 wherein the pulsing means pulses the current at a duty cycle of between 20% and 40%.

3. Apparatus according to claim 2 wherein the pulsing means pulses the current at a duty cycle of 28%.

4. Apparatus according to any one of the preceding claims wherein the current is pulsed at a frequency of between 0.65 Hz and 0.85 Hz.

5. Apparatus according to claim 4 wherein the current is pulsed at a frequency of 0.75 Hz.

6. Apparatus according to any one of the preceding claims wherein the pulsing means includes a power supply; a chopper circuit; a capacitor; an inductor and a diode.

7. Apparatus according to claim 6 wherein the capacitor has a capacitance of between 200 mF and 350 mF.

8. Apparatus according to claim 7 wherein the capacitor has a capacitance of 272 mF.

9. Apparatus according to any one of claims 6 to 8 wherein the inductor has an inductance of between 3 mH and 7 mH.

10. Apparatus according to claim 9 wherein the inductor has an inductance of 5 mH.

11. Apparatus according to any one of claims 6 to 10 wherein the power supply supplies a DC voltage of 12 V.

12. Apparatus according to any one of the preceding claims wherein the electrolytic solution is in the form of a sodium hydroxide solution in water.

13. Apparatus according to any one of the preceding claims wherein the first electrode is an outer electrode, with the second electrode being an inner electrode disposed within the outer electrode.

14. Apparatus according to any one of the preceding claims wherein a plurality of intermediate floating electrodes are disposed between the first and second electrodes.

15. Apparatus according to any one of the preceding claims wherein the pulsing means is connected to the first and second electrodes.

16. Apparatus according to any one of the preceding claims wherein the electrodes are interposed between two insulators.

17. Apparatus according to claim 14 wherein a passage is provided in the form of a plurality of annular channels for the electrolytic solution and which is defined between the first or outer electrode, the intermediate floating electrodes and the second or inner electrode.

18. Apparatus according to claim 17 wherein the electrodes are tubular and are arranged concentrically with each other.

19. A method for the production of combustible fluid from an aqueous electrolytic solution including the steps of:

- providing an aqueous electrolytic solution
- disposing the solution in an electrolysing cell between two spaced electrodes;
- applying a pulsed current to the electrolysing cell, the current having a duty cycle of less that 50%; and
- electrolysing the electrolytic solution.

20. A method according to claim 19 wherein the pulsed current has a duty cycle of between 20% and 40%.

21. A method according to claim 20 wherein the pulsed current has a duty cycle of 28%.

22. A method according to claim 19 wherein the step of applying a pulsed current to the electrolysing cell includes the step of pulsing the current at a frequency of between 0.65 Hz and 0.85 Hz.

23. A method according to claim 22 wherein the step of applying a pulsed current to the electrolysing cell includes the step of pulsing the current at a frequency of 0.75 Hz.

24. A method according to any one of claims 19 to 23 wherein the step of disposing the solution in the electrolysing cell includes the further step of disposing the solution between a first outer electrode, a second inner electrode disposed within the outer electrode, and a plurality of intermediate floating electrodes disposed between the first and second electrodes.

25. Apparatus substantially as herein described and as illustrated in the accompanying drawings.

26. A method for the production of combustible fluid from an electrolytic solution substantially as herein described with reference to the accompanying drawings.

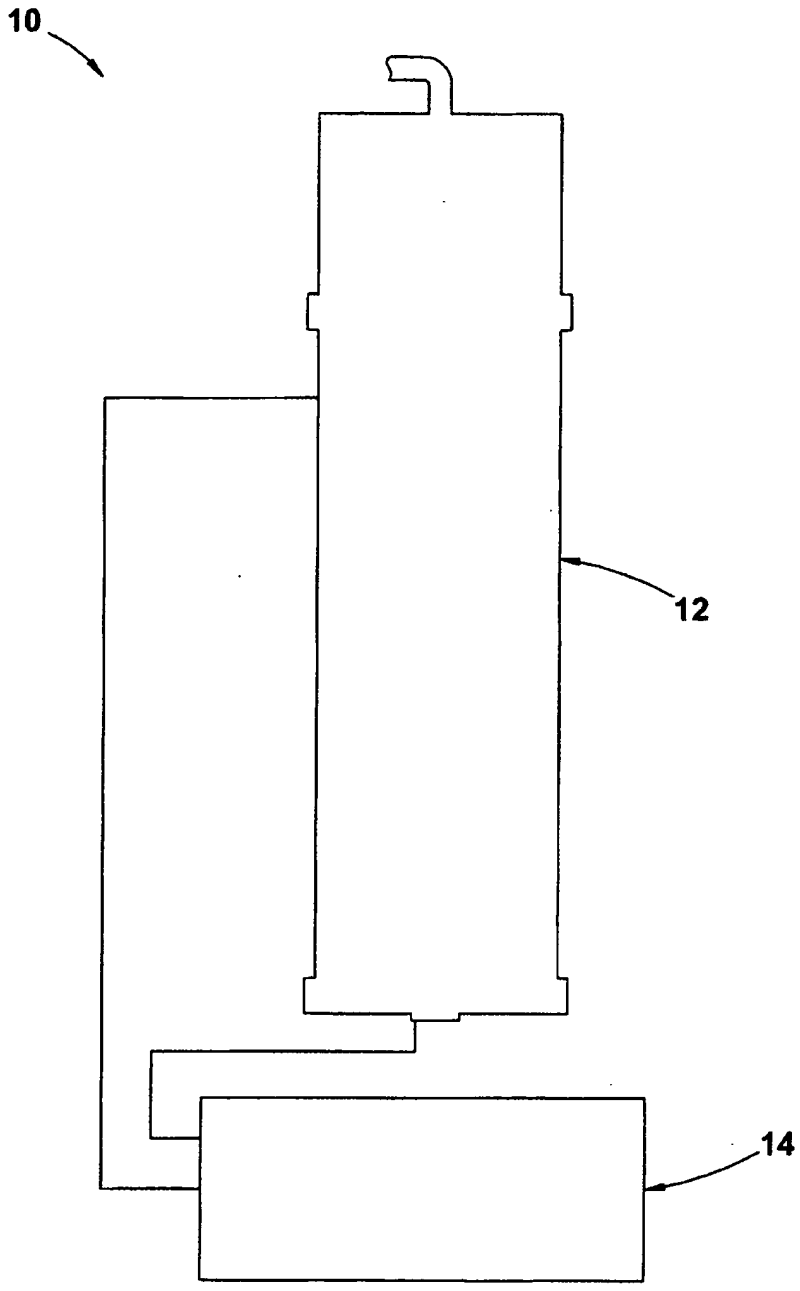


FIGURE 1

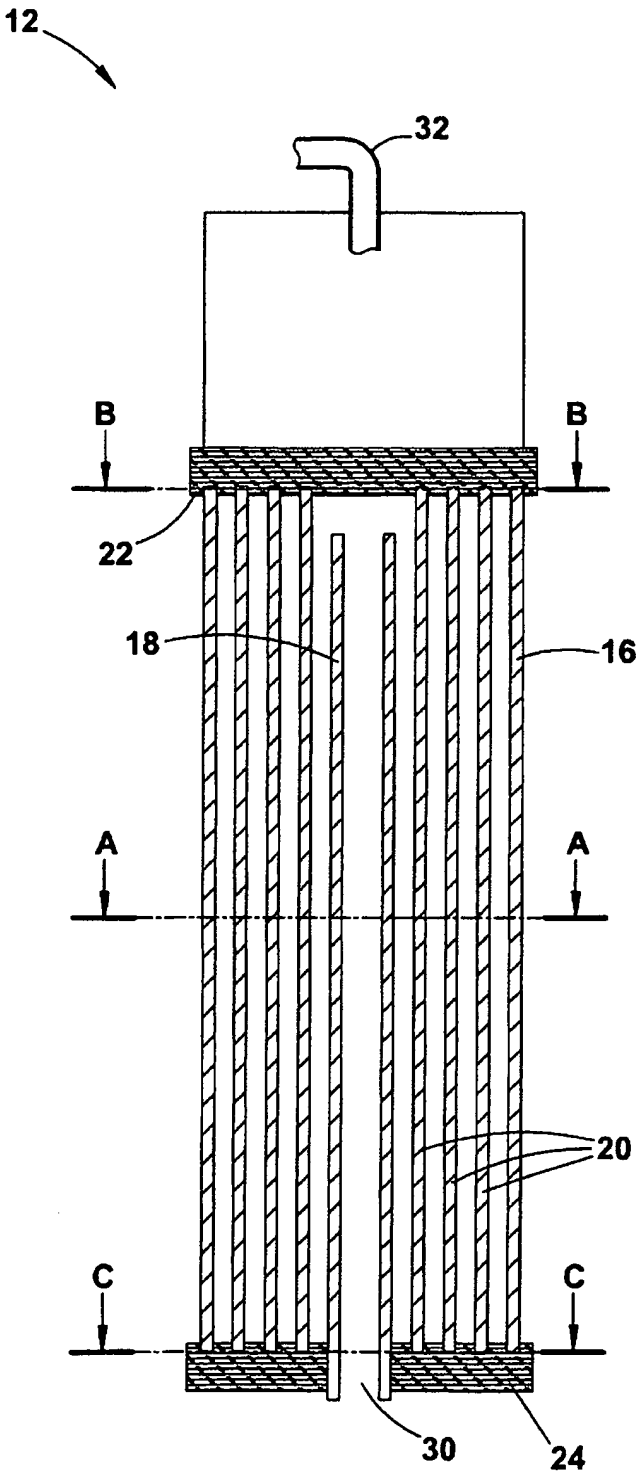


FIGURE 2

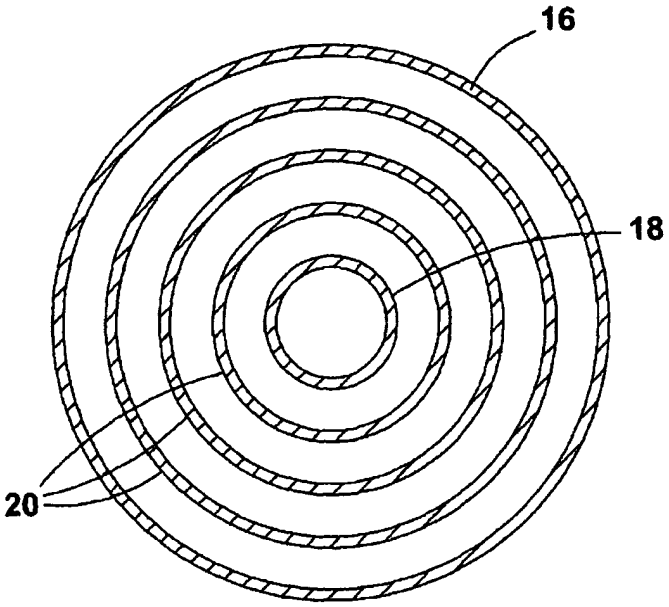


FIGURE 3(SECTION A-A)

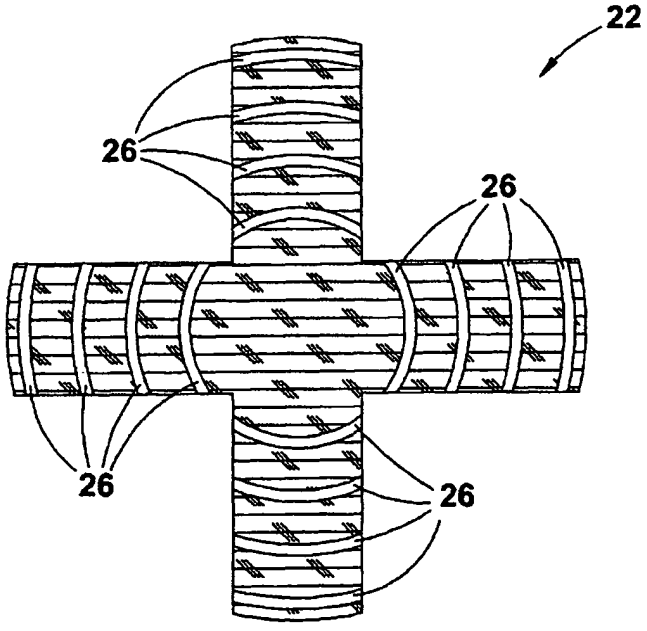


FIGURE 4(SECTION B-B)

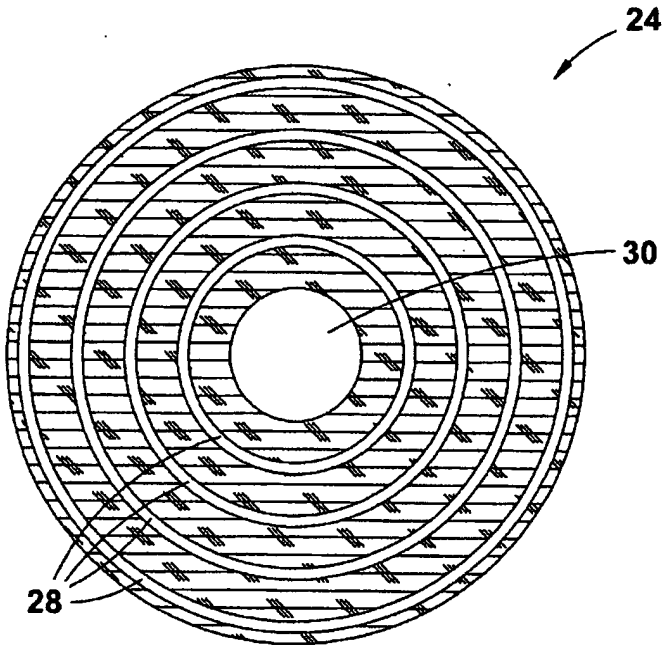
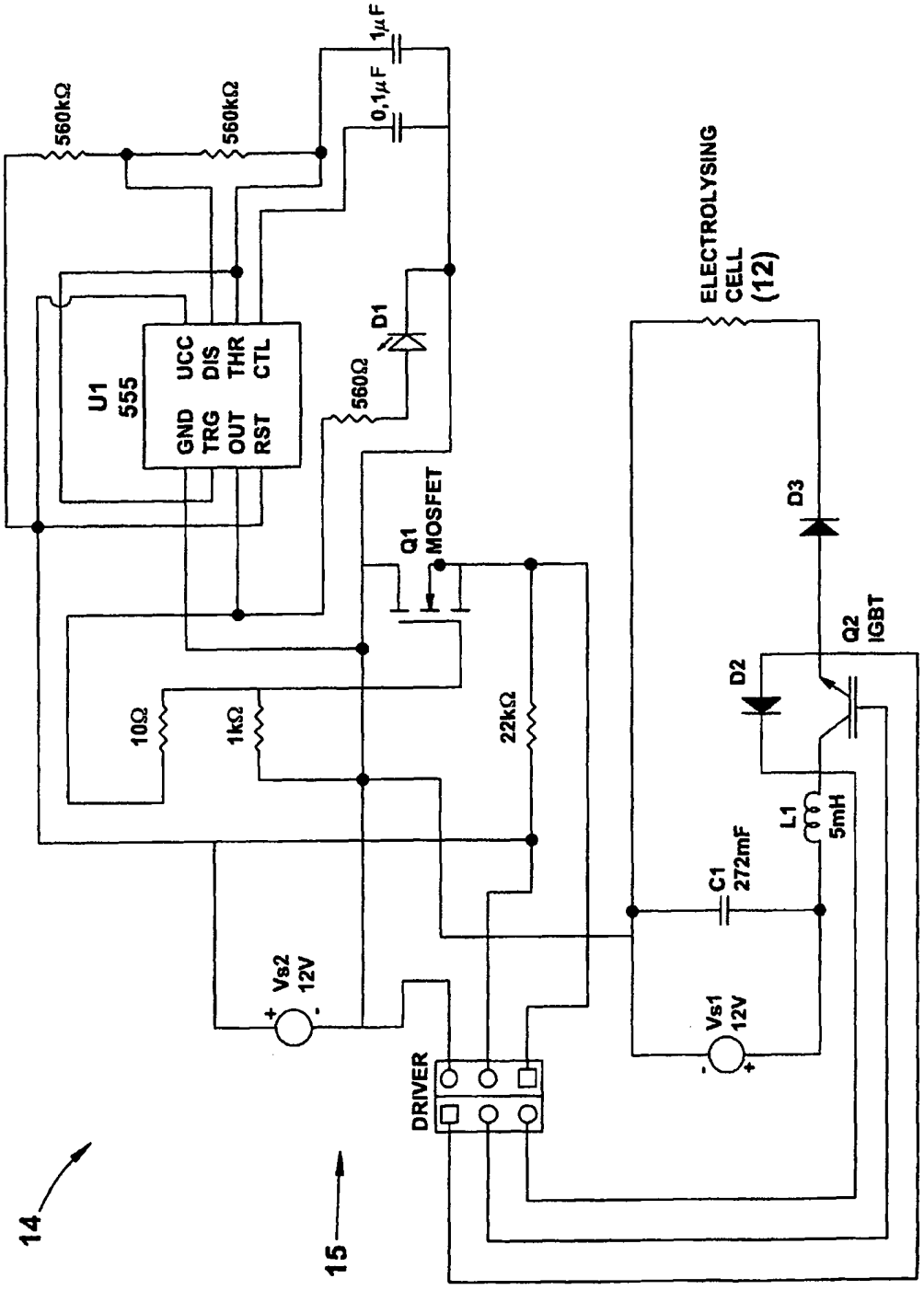


FIGURE 5(SECTION C-C)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Q1
MOSFET
10Ω
1kΩ
22kΩ
ELECTROLYSING
CELL
(12)
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Vs2
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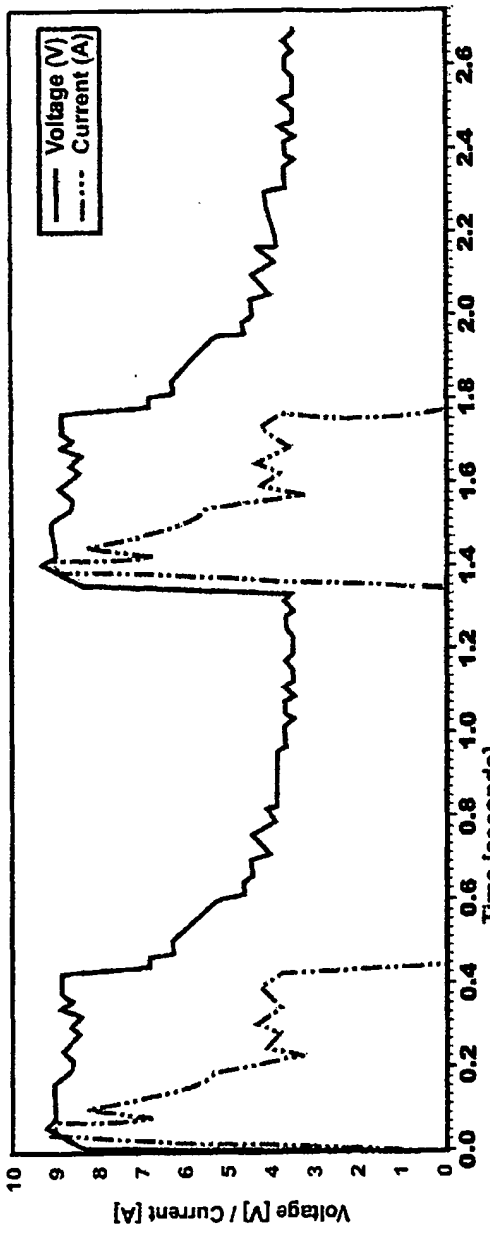
DRIVER
14
15

FIGURE 6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Current (A)
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FIGURE 7